is compressed along the axis of the long diagonal of the parallelogram by support flexures at each end. The expansion of the PZT along the long diagonal causes the ends of the short diagonal to move towards each with a motion amplified by a factor of 3 or 4. The parallel flexures are used to eliminate unwanted twisting and vibration modes such that a small mirror will not tilt when translated by the amplifier. The support flexures that hold the PZT allow a symmetrical expansion of the piezo within the amplifier. The amplifier is designed to be completely symmetric and balanced such that inertia forces are nulled. This provides mechanical stability

that allows rapid (100-Hz) sampling without inducing vibrations. Optical interferometers normally obtain the mechanical stability and momentum compensation by using an additional piezo stack mounted back-to-back with the first piezo so that the second one has motions that are equal but opposite in direction. By mounting the stack symmetrically with the support flexures the stack expands equally about its center, does not induce vibrations, and does not require momentum compensation.

This new mechanical amplifier provides both a longer stroke for standard piezo stacks and the necessary mechanical stabil-

ity through an ingenious mounting arrangement. The device is made of titanium and machined using a wire EDM (electrical-discharge machining) process so as to be as strong and lightweight as possible. It is compact using only a single piezo stack, making it ideally suited for phase-measurement in a cryogenic environment.

This work was done by James Moore, Mark Swain, Peter Lawson, and Robert Calvet of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP [see page 1].*
NPO-30289

Swell Sleeves for Testing Explosive Devices

A device is detonated in a sleeve and the resultant swelling is measured.

Lyndon B. Johnson Space Center, Houston, Texas

A method of testing explosive and pyrotechnic devices involves exploding the devices inside swell sleeves. Swell sleeves have been used previously for measuring forces. In the present method, they are used to obtain quantitative indications of the energy released in explosions of the devices under test.

A swell sleeve is basically a thick-walled, hollow metal cylinder threaded at one end to accept a threaded surface on a device to be tested (see Figure 1). Once the device has been tightly threaded in place in the swell sleeve, the device-and-swell-sleeve assembly is placed in a test fixture, then the device is detonated.

After the explosion, the assembly is removed from the test fixture and placed in a coordinate-measuring machine for measurement of the diameter of the swell sleeve as a function of axial position. For each axial position, the original diameter of the sleeve is subtracted from the diameter of the sleeve as swollen by the explosion to obtain the diametral swelling as a function of axial position (see Figure 2). The amount of swelling is taken as a measure of the energy released in the explosion. The amount of swelling can be compared to a standard amount of swelling to determine whether the pyrotechnic device functioned as specified.

This work was done by Todd J. Hinkel, Richard J. Dean, Carl W. Hohmann, Scott C. Hacker, and Douglas W. Harrington of **Johnson Space Center** *and James W. Bacak of Lockheed Engineering and Sciences Co. Further information is contained in a TSP [see page 1].*
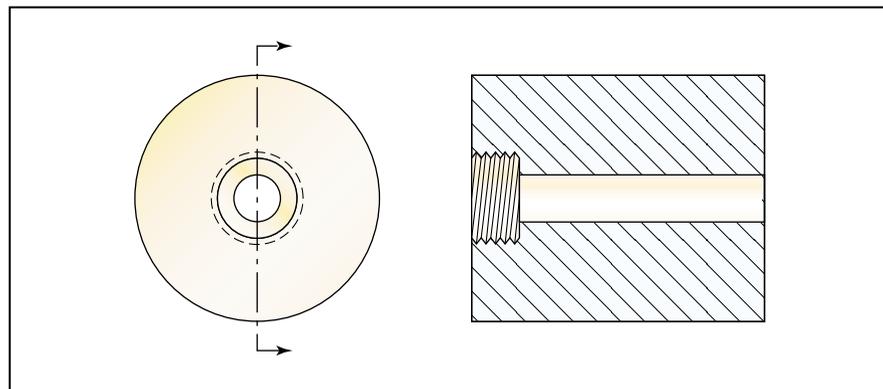*MSC-23306*

Figure 1. A **Swell Sleeve** is designed and fabricated to accept an explosive device. It is so named because its wall is thick enough not to burst yet thin enough to swell measurably when the device is exploded within it.
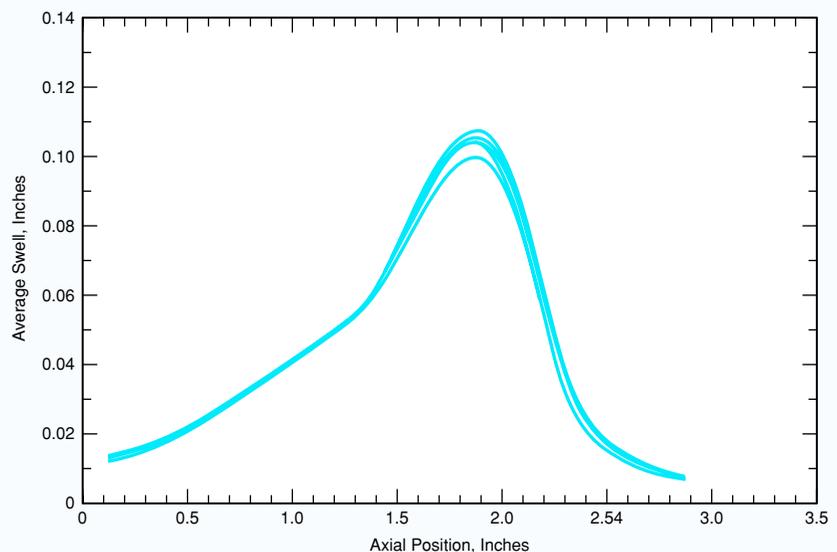

Figure 2. These **Diametral Swells** as functions of axial position were obtained in swell-sleeve tests of explosive devices used to separate an external-tank assembly from a space shuttle.